6/10/83 U9660-2 A

THE MICHIGAN ECONOMY

Volume 2 No. 1
JANUARY 1983

Published by the
Bureau of Business Research
School of Business
Administration
The Prentis Building

Wayne State University

DETROIT, MICHIGAN 48202

Published monthly, except July and August, when bimonthly. Third class postage paid at Detroit, Michigan.

ISSN: 0730-272X

The Product Liability Crisis

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Michigan's business community experienced a sizable increase in its product liability exposure during the 1970s. Other states were also involved in this product liability "crisis." The United States Commerce Department's Task Force on Product Liability and Accident Compensation reported that the product liability premiums paid by American business increased a staggering 280 percent between 1970 and 1976.[1] Another study showed that insurance companies' revenues from product liability premiums rose from $1.13 billion in 1975 to $2.75 billion in 1978.[2]

Some observers blame the crisis on the growing number of attorneys and on a disturbing disposition of consumers to sue for virtually any product problem.[3] Others point a finger at the state judges who consistently hold business strictly liable for the injuries caused by their defective products.[4]

The data show indisputably that the insurance industry was increasingly exposed to product liability settlements during the 1970s. First, there were many more suits filed. The 158 percent increase in product liability suits in federal courts from 1974 to 1977 is a good illustration.[5] Second, the awards were much larger. The average out-of-court settlement for a bodily injury claim caused by a defective product rose from $6,800 in 1972 to $19,500 in 1974.[6] The average judgment awarded in a product liability trial in 1975 nearly doubled the average award of only five years earlier.[7] Finally, these rising awards were accompanied by rising defense costs. For every dollar paid to a plaintiff, insurance companies paid another thirty-five cents in attorney fees and related costs.[8]

Critics of the insurance industry consistently downplay these facts. They gainsay the higher awards as simply reflecting generally higher health care and labor costs.[9] Some critics maintain that the product liability crisis was a sham conjured up to justify the enormous increases in premium rates.[10] They argue that the premium increases were imposed, not to cover the larger product liability awards, but to recoup serious stock market losses and quite unrelated underwriting losses suffered by the insurance industry during the economic downturn of the mid-1970s.[11] Other critics maintain that the insurance industry's rate-making process is unsophisticated and attribute the higher product liability premiums to "panic pricing."[12]

In most industries the cost of product liability insurance, even with the increased premiums, is less than 1 percent of sales revenues. Yet industries with high-risk products, such as automobile parts, industrial machinery, industrial chemicals, pharmaceuticals, medical devices, and sporting goods, are paying as much as 10 percent of their sales for product liability insurance premiums.[13]

In retrospect, the Michigan legislature faced a product liability crisis whose causes remained a mystery. But the steadily mounting premium costs were a fact. In December 1978 Michigan's legislators cautiously asserted their power to set the parameters for the future product liability decisions of our state's judges. Ironically, the legis-

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lation that was intended to shield Michigan's business from soaring liability premiums eventually became a statute that actually increased their liability exposure.

RESPONSE OF STATE LEGISLATURES

Michigan and a few other states now require insurers to provide a data base that could justify their ratemaking.[14] Each insurance company offering product liability coverage in Michigan must file a report with the state's insurance commissioner on its state and national experience with both product liability claims and coverage cancellations. These reporting requirements should help to correct a situation in which there "just is no statistical base to provide accuracy in product liability rate making."[15]

Undaunted by this information void, Michigan and twenty-two other states passed product liability legislation in response to the soaring insurance costs. The remarkable variety of these responses demonstrates the vitality of our federal system but not a commitment to uniformity in the American legal environment. Managers should be cautioned that product liability laws vary dramatically from state to state and that some states bar types or classes of claims permitted elsewhere.

MICHIGAN PRODUCT LIABILITY STATUTE

As the proposed legislation progressed through the House Committee on Economic Development, a parade of lobbyists presented their positions to the legislators. Several earlier versions of the bill were much more favorable to the business and manufacturing communities than the bill finally brought out of committee and eventually enacted into law.[16] The statute that emerged is largely a codification of the product liability law that had already been developed by Michigan's courts, but in several areas our businesses' liability exposure was expanded.[17]

NATURE OF A PRODUCT LIABILITY CASE

In a product liability case, the plaintiff seeks recovery for a personal injury or property damage caused by a defective product. The plaintiff will usually be a purchaser or user of the product but may simply be a bystander. The defendant will often be the product's manufacturer, but occasionally every seller in the entire chain of distribution will be sued.

Michigan's new statute creates a "product liability action" which encompasses any action, based on any legal theory of liability, brought because of death or injury to a person or for property damage. This injury may be caused by the design, manufacture, testing, or marketing of a product. Michigan's all-inclusive definition of a product liability action incorporates into one form of action those suits which were previously brought under both contract and tort theories. The statute does not explicitly set out the elements necessary to establish a case in this new product liability action. Consequently, Michigan courts will continue to rely on the established laws of warranty and negligence to supply the needed elements.

When someone sues under a contract theory, he or she is usually suing for the breach of a warranty. The injured party must prove that the seller warranted the product, that the warranty was breached, and that the breach caused the injury. The warranty may be either expressed or implied. An express warranty is present when the seller makes "any affirmation of fact or promise to the buyer which relates to the goods and becomes part of the basis of the bargain."[18] For example, if a seller says, "This printer is compatible with an IBM 360 series computer," and it is not, an express warranty has been breached. An implied warranty arises by operation of law without any statement or action by the seller. It is a quality standard created to protect the consumer from defective goods. The implied warranty of merchantability requires that a product "pass without objection in the trade under contract description," and "be fit for the ordinary purposes for which such goods are used."[19] The seller of a watch that loses a half hour per day has breached a warranty, even when no claim of accuracy was made to the buyer.

In the past, plaintiffs could bring a suit for breach of warranty only against those from whom they had purchased the item. Today anyone in the chain of distribution—the manufacturer, the wholesaler, or the retailer—can be sued directly.

When a party sues under a tort theory in Michigan, he or she is alleging negligence or fault. Michigan presently has not adopted the doctrine of strict liability, so the injured plaintiff must show that the manufacturer or seller did not exercise reasonable care in the production or sale of the product. What constitutes "reasonable care" has expanded significantly in recent years. Manufacturers have been found negligent when they failed to test a product for safe performance after extended but foreseeable wear and tear has occurred. A jury could find the manufacturer of a laundromat extractor negligent when the fifteen-year-old machine failed to shut off when the top was raised. Courts have found negligence in a product design when the plaintiff was injured while misusing the product in a foreseeable manner. A screwdriver manufacturer would be liable for an eye injury suffered when the tool was being used to pry open a can of paint.

STANDARDS OF CONDUCT

An interesting perspective on Michigan's new statute can be gained by comparing the law's final form with the language of the bill while it was being deliberated in the House Committee on Economic Development. There are several instances where the proposed bill made the proof of certain facts by a business a complete defense. Yet the final form says that proof of those facts is merely admissible.

Two good examples are proofs that the conduct of the manufacturer or other seller conformed to "generally recognized and prevailing nongovernmental standards"[20] or "was done pursuant to the federal state law, rules or regulations"[21] which existed at the time the prod-

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HUMAN RESOURCE IMPLICATIONS OF ROBOTICS

by H. ALLEN HUNT, *acting manager of research, and* TIMOTHY L. HUNT, *senior research economist, W. E. Upjohn Institute for Employment Research*

This research was sponsored by the Michigan Occupational Information Coordinating Committee (MOICC). Material for this article is taken from a research summary. The final report will be available in March 1983.

A robot is a reprogrammable, multifunctional manipulator. A robot can perform the same task on identical workpieces, repetitively; it can perform multiple tasks on the same workpiece; or it can be reprogrammed to perform entirely new tasks.

The Robot Institute of America (RIA), the trade association of robot manufacturers and corporate users, reports that there were approximately 4,700 robots in the U.S. in 1981. By the end of 1982 we estimate that 6,600 to 7,000 robots will be operating in U.S. factories. We estimate that employment in U.S. robot manufacturing is roughly 2,000 workers nationwide today. This should make it clear that most of the employment impacts to be discussed are in the future. The growth in application of industrial robots and the employment implications of that growth both have to be projected because of the very limited empirical base to date.

Unlike R2D2 and C3PO of the movie *Star Wars*, robots of today are essentially "dumb machines." They are generally immobile; they usually lack any visual or tactile sensor perception, and therefore cannot adapt to their environment in any way. Generally they are no faster than human workers, but they are tireless. In layman's trms that means a robot can reproduce a specific range of motions for which it has been programmed, but it does not know if it is really holding the part it is supposed to be or if the work was done correctly. Although the trade literature makes much of the reprogrammability of robots, few robots are truly reprogrammed.

The proven applications of robots today are welding, painting, and various pick-and-place operations. Assembly robots are viewed as the number one growth application of the future, but presently robots cannot perform most assembly tasks with consistency in an industrial environment at a reasonable cost. Given all of the media attention to robots, it is surprising that there are so few actually in operation. Part of the reason is to be found in the limited industrial applications so far developed.

Virtually all robots can be found in manufacturing firms, and the bulk are located in what is sometimes referred to as the metalworking sector. The auto industry is the primary user of robots today with approximately 25 percent of all robot installations. Again, the surprise is that so few industries are actually using robots, but is it also true that these heavy industries are particularly concentrated in the traditional industrial heartland of the five Great Lakes States.

Robots should be viewed as a capital investment in automated equipment. In terms of cost, flexibility, and capability, robots are actually a compromise between the extremes of custom production and dedicated automation. Set-up time for a robot far exceeds that of a human operator in custom production, yet the speed of a robot is no match for dedicated automated equipment. Likewise, robots are no match for the flexible skills of a precision machinist, nor can a robot repeat a single task as perfectly as highly specialized automated equipment. In view of these facts, robots today are being applied in semi-automated batch or mass production facilities where the human worker or the type of work itself already limits the speed of the overall facility. The robot, once installed, appears to be just one more piece of dedicated automated equipment.

In the future such production facilities may be computer controlled with robots moving the workpiece from machine to machine. If an entire "production cell' is computer controlled, then human workers will not be needed except for maintenance, provision of the necessary material inputs, and transportation for the final output. If off-line reprogramming capability becomes available, then human operators will not even be needed to switch to the next batch. Such "flexible automated systems" will ultimately be linked together and lead to the completely automated factory of the future.

ROBOT POPULATION IN 1990

The projections of occupational impact in this study are the result of first forecasting the U.S. robot population by industry and application areas within those industries. This approach constrains the employment impacts to reflect the actual expected sales of robots. In this way a consistent economic framework is established within which it is possible to estimate not only the population of robots and job displacement but also the job creation resulting therefrom. The consistency is also very helpful in avoiding unrealistic conclusions.

Our data were gathered from published sources and through interviews with robot manufacturers, corporate users of robots, and other experts. While some judgment was undeniably necessary, we attempted to maintain objectivity throughout our efforts. In the full study, all judgments and assumptions are explicitly stated and, thus, are available for review. However, due to the space limitations of this summary, emphasis is on concusions father than methodology.

We expect strong growth in the utilization of industrial robots in the decade of the 1980s. By 1990 the total robot population in the U.S. will range from a minimum of 50,000 to a maximum of 100,000 units. Given our estimate of the year-end 1982 population of approximately 6,800 units, that implies an average annual growth rate of between 30 and 40 percent for the eight years of the forecast period, or roughly a seven- to fourteen-fold increase in the total population of robots.

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Michigan Economic Indicators

Item	Year previous of latest month	Previous month	Latest month
Manufacturing workers:			
Average weekly hours, Michigan	39.7	39.8	40.7 (Nov.)
Average weekly hours, U.S.	39.9	39.0	39.2 (Nov.)
Average hourly earnings, Michigan ($)	10.86	11.12	11.22 (Nov.)
Average hourly earnings, U.S. ($)	8.27	8.56	8.62 (Nov.)
U.S. motor vehicle production (units)	535,328	556,457	530,296 (Nov.)
Michigan electricity usage (mil. kwh.):			
Industrial (mil. kwh.)	2,721	2,490	2,446 (Aug.)
Residential (mil. kwh.)	1,940	1,829	1,836 (Aug.)
Raw steel production:			
Michigan (000 net tons)	590	413	360 (Nov.)
United States (000 net tons)	7,962	5,262	4,546 (Nov.)
Consumer price index (1967 = 100)			
Detroit area	279.1	295.2	296.0 (Nov.)
United States	279.9	294.1	293.6 (Nov.)
U.S. producer price index (1967 = 100)	295.5	299.2	300.4 (Nov.)
Michigan farm prices received index (1977 = 100)	129	115	116 (Nov.)

SOURCE: U.S. Bureau of the Census; U.S. Bureau of Labor Statistics; Michigan Crop Reporting Service; Ward's Automotive Reports; American Iron and Steel Institute; and Energy Information Administraton.

Contracts for Future Building, Cumulative: 1981 and 1982

(Thousands of Dollars)

Area	Nonresidential 1981	Nonresidential 1982	Nonresidential Percentage Change	Residential 1981	Residential 1982	Residential Percentage Change	Total[a] 1981	Total[a] 1982	Total[a] Percentage Change
Ann Arbor	55,692	72,400	+ 30	32,917	19,267	− 41	88,609	91,667	+ 3
Battle Creek	16,130	48,764	+202	14,210	10,430	− 27	30,340	59,194	+ 95
Bay City	9,731	7,736	− 21	6,409	7,845	+ 22	16,140	15,581	− 3
Detroit	727,472	511,253	− 30	328,102	316,754	− 3	1,055,574	828,077	− 22
Flint	40,199	44,169	+ 10	35,940	26,081	− 27	76,059	70,250	− 8
Grand Rapids	126,207	124,288	− 2	123,956	78,199	− 37	250,163	202,407	− 19
Jackson	18,797	7,309	− 61	17,118	8,851	− 48	35,915	16,160	− 55
Kalamazoo-Portage	45,836	135,950	−197	81,967	32,483	− 60	127,803	168,433	+ 32
Lansing-East Lansing	60,175	46,929	− 22	93,549	41,868	− 55	153,724	88,797	− 42
Muskegon-Norton Shores-Muskegon Heights	14,396	23,981	+ 76	23,413	14,321	− 39	37,809	38,302	+ 1
Saginaw	16,371	22,167	+ 35	21,616	15,896	− 26	285,133	238,877	− 16
Toledo	150,857	139,626	− 7	134,276	99,251	− 26	37,987	38,063	+ 0.2
Michigan	1,336,850	1,149,956	− 14	1,122,958	856,444	− 24	2,459,808	2,006,400	− 18
United States	60,087,700	59,207,500	− 1	60,164,000	58,076,300	− 3	120,251,700	117,283,800	− 2

SOURCE: F. W. Dodge Division of McGraw-Hill Information Systems Company, news releases.

Note: Battle Creek includes Barry and Calhoun counties; Detroit includes Lapeer, Livingston, Macomb, Oakland, St. Clair, and Wayne counties; Flint includes Genesee and Shiawassee counties; Grand Rapids includes Kent and Ottawa counties; Kalamazoo-Portage includes Kalamazoo and Van Buren counties; Lansing-East Lansing includes Clinton, Eaton, Ingham, and Ionia counties; Muskegon-Norton Shores-Muskegon Heights includes Muskegon and Oceana counties; and Toledo includes Monroe County, Michigan, and Fulton, Lucas, Ottawa, and Wood counties, Ohio.

a. Excludes nonbuilding construction contracts. This category comprises streets and highways, bridges, dams, reservoirs, river and harbor developments, sewerage and water supply systems, missile and space flight facilities, airports, utilities, and communication systems. For Michigan the 1981 and 1982 figures for nonbuilding construction contracts were $798,406,000 and $482,218,000 respectively, or a decrease of 40 percent. For the United States they were $33,227,900,000 and $37,335,600,000 respectively, or an increase of 12 percent. Total building and nonbuilding construction contracts declined by 24 percent in Michigan and increased 1 percent nationwide.

THE PRODUCT LIABILITY CRISIS

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uct was sold. Under the initial language, proof that an extension cord conformed to the quality of Underwriters Laboratories would have barred a suit against the manufacturer or a retailer. Under the new law, this evidence simply "shall be admissible." Consumer groups, the State Bar of Michigan, and the Michigan Trial Lawyers Association, the formidable lobby of plaintiffs' attorneys, apparently convinced the legislators that an industry should not be allowed to define its own standard of conduct. The implications is that without an "outsider's" view the industry or trade associations would perpetuate substandard, unsafe technologies.[22] The statute gives those making or selling a product no assurance that meeting industry safety standards will foreclose liability. Instead, the statute promotes litigation as a mechanism to prod a company into spending substantial amounts of money to develop only marginally safer products simply to provide some modicum of assurance that they will not be found liable.

Similarly, meeting a government safety standard provides a business with only minimal protection. Evidence that a product met the relevant governmental standard is admissible at the trial but is not a defense. The legislation allows a court to hold an automobile manufacturer to a higher safety standard than the standard thought appropriate by the state or federal regulatory agency that presumably has an expertise in this product. The agencies are apparently thought to be held captive by those they purport to regulate. Perhaps the legislature was leery of the heavy reliance of the regulators on technical input from industry sources.[23] But the bottom line is that the legislature allows the judiciary to second-guess the safety standards set by the executive branch's regulatory agencies. Meeting and even exceeding the product safety standards set by the industry or the government will not bar a business from being held liable.

STATE OF THE ART

Advocates of Michigan's business community presented the House Committee on Economic Development with a bill that would have barred evidence of a change in technology introduced after the initial sale of the product. These "state of the art" statutes have two purposes. First, the barring of evidence of a subsequent improvement reinforces those managers seeking to use safer technology as the change cannot be used to improve the quality of their older product line. Second, there is a fairness notion that is offended when we hold a business to a subsequently developed, higher technological standard that was not reasonably feasible or was simply unknown at the time the product was designed.

Interestingly, even the business supporters would have settled for a standard based on the technology at the date of the initial sale, not at the earlier time the product was designed. The new statute only bars evidence of change in technology occurring after the date of the injury.[24] This difference between the "date of the sale" and the "date of the injury" appears subtle, but the impact can be devastating to a jury's perception of a defendant.[25] For example, assume that an automaker were to develop "bendable glass" *after* the sale of the car involved in a serious facial injury but *before* the accident occurred. That new development would be admitted to assist the jury in deciding if the auto's glass had a defective design. Michigan has a sizable group of plaintiffs' attorneys who will make excellent use of this expanded body of admissible evidence.

WARNINGS

The initial bill stated that the presence of a warning which gave notice to a user of a product's dangers would be a defense if the user ignored the warning and was injured. The enacted law states that the presence of the warning is merely admissible evidence.[26]

STATUTES OF LIMITATION AND REPOSE

A statute of limitation establishes a time limit from the date the action accrues within which a suit must be brought. The legislature rejected a proposal for a six-month limit in favor of three years.[27]

A statute of repose bars a suit for an injury from a very old product. The final language did not contain a statute of repose. Some manufacturers contend that the present law requires a design where all the product's parts collapse at once. A fifteen-year-old laundromat extractor that is still running strong can mean potential liability if the shut-off mechanism no longer works when the top is raised.

COMPARATIVE NEGLIGENCE

The new product liability act introduced the plaintiff-oriented theory of comparative negligence into Michigan law.[28] Two months after the legislature ushered in comparative negligence, the theory was embraced by the Michigan Supreme Court in the landmark decision of *Placek v. City of Sterling Heights*.[29]

Before comparative negligence became the law of Michigan, if a plantiff was injured, in part because of negligence, contributory negligence would bar recovery. The new statute provides that the damages suffered by the plaintiff shall be diminished in proportion to the amount of negligence attributed to the plaintiff. If a careless worker is injured by negligently designed safety equipment on a drill press, carelessness will no longer bar recovery. If one-third of the negligence can be attributed to carelessness, recovery will be accordingly reduced. Today, this plaintiff would receive two-thirds of damages; in the past, nothing.

CONCLUSION

Legislation was introduced in response to the complaint of manufacturers and other businesses that they were paying exorbitant rates for their product liability insurance or having difficulty in obtaining the insurance coverage at all. Eventually, the fanfare died down, the voters were counted, and what emerged was a very different body of law than originally proposed. If the prod-

uct liability premiums paid by Michigan businesses level off or begin to drop, the new product liability statute almost certainly will not have been the cause.

Footnotes

1. U.S. Dept. of Commerce, *Interagency Task Force on Product Liability Final Report (1977)*, III-11 (hereinafter cited as *Task Force Report*).
2. "The Devils in Our Product Liability Laws," *Business Week*, 12 February 1979, 72.
3. "When Firms Get Sued for 'Faulty' Goods," *U.S. News and World Report*, 22 May 1978, 93; National Association of Manufacturers, *Issue Brief on Products Liability*, 1 February 1982, 1.
4. "Devils in Our Laws," 72.
5. The Research Group, Inc., Interagency Task Force on Product Liability, *Final Report on the Legal Study (1977)*, 1:10.
6. McKinsey & Company, Inc., Interagency Task Force on Product Liability, *Final Report of the Insurance Study (1977)*, 4.
7. The Research Group, Inc., Interagency Task Force on Product Liability, *Final Report of the Legal Study (1977)*, 3:4.
8. Insurance Services Office, *Product Liability Closed Claim Survey: A Technical Analysis of Survey Results (1977)*, 11.
9. Begam, "One More Insurance 'Crisis'," *Trial* 12 (November, 1976): 46, 49.
10. Johnson, "Behind the Hype on Product Liability," *The Forum* 14 (Fall, 1978): 317, 324; Birnbaum, "Legislative Reform or Retreat? A Response to the Product Liability Crisis," *The Forum* 14 (Fall, 1978): 251, 255.
11. Begam, "Crisis," 47; House Committee on Small Business, Product Liability Insurance, H.R. Report No. 997, 95th Congress, 2d Session (1978), remarks of Ralph Nader.
12. *Task Force Report*, I-22; *Summary*, 12.
13. *Task Force Report Summary*, 12.
14. Mich. Comp. Laws §500.438 (1976).
15. Ghiardi, *Products Liability—Where is the Borderline Now?, The Forum* 13 (Fall, 1977): 206, 210.
16. Schaden, "Product Liability: Synthetic Crisis, Defective Cure," *Michigan State Bar Journal* (January, 1978): 26.
17. Mich. Comp. Laws §600.2945–600.2948, §600.5805, 600.5827, 600.5833 (1978).
18. Mich. Comp. Laws §400.2313(1)(a) (1972).
19. Mich. Comp. Laws §400.2314(2)(a) and (c) (1979).
20. Mich. Comp. Laws §600.2946(1) (1978).
21. Mich. Comp. Laws §600.2946(2) (1978).
22. Schaden, "Product Liability," 27.
23. Ibid., 28.
24. Mich. Comp. Laws §600.2946(3) (1978).
25. Basta, "Michigan's New Product Liability Law," *The Detroiter*, (February, 1981): 9.
26. Mich. Comp. Laws §600.2948 (1978).
27. Mich. Comp. Laws §600.5805(9) (1978).
28. Mich. Comp. Laws §600.2949(1) (1978).
29. *Placek v. City of Sterling Heights*, 405 Mich. 638 (1979).

IMPLICATIONS OF ROBOTICS

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This range is intended to contain the actual robot population with a high probability level, and allows for variation in interest rates, capital investment climate, auto industry recovery, and rate of economic growth. We are confident this range will contain the 1990 robot population. That means we do not expect the total collapse of the automobile industry, a major renaissance in U.S. capital investment, the early development of non-manufacturing robot applications, or the widespread adoption of robotics technology by small firms.

The U.S. population of robots is developed separately for the auto industry and all other manufacturing. This is partly to take advantage of the fact that the auto producers have announced goals for robot installations which could be factored into our robot population forecast. It also reflects the fact that the major impact of robots in the State of Michigan will be in the auto industry. Our forecast of the robot population sees 15,000 to 25,000 robots employed in the U.S. auto industry by 1990.

The Michigan robot population in 1990 is derived from the U.S. total by assigning the robots in proportion to production worker employment, both in the auto industry and in all other manufacturing. The result is a forecast of roughly 7,000 to 12,000 robots in Michigan in 1990. Somewhere between 5,000 and 9,000 of these will be employed in the auto industry, roughly three-fourths of the total. Consequently we conclude that, outside the auto industry, robots will have only a minor impact in the State of Michigan during the forecast period.

GROSS CUMULATIVE DISPLACEMENT EFFECTS BY 1990

Before discussing the displacement effects of robots, it is important to insure that the meaning of the term "displacement" is clear. We use displacement to refer to the elimination of particular jobs, not to the layoff of individual workers. It clearly is possible that the displacement of a particular job by a robot might lead to the layoff of the occupant of that job, but it is not necessary. Layoff refers to the involuntary separation of the worker from the firm; displacement refers to the elimination of the job itself without any assumption as to whether the worker in that job is separated from the firm, either voluntarily or involuntarily.

Utilizing the Michigan robot forecast by industry, and the assumption of a gross displacement rate of two jobs per robot which was strongly supported in our interviews, estimates of gross job displacement are derived. We estimate that robots in Michigan will eliminate between 13,500 and 24,000 jobs by 1990. Between 10,500 and 18,000 of these will be in the auto industry, while 3,000 to 6,000 non-auto jobs will also be eliminated. In relative terms, over 75 percent of the job losses in Michigan are expected to be in the auto industry.

In addition to the assignment of robots by location and industry, it was necessary to forecast the applica-

tions for which they will be used. This is required if the robot population forecast is to be useful in predicting occupational displacement. Otherwise there is no way to connect the robots with the work content of specific jobs. The application areas used in this study are welding, assembly, painting, machine loading and unloading, and other.

When the robot forecast by application area and industry is matched against an occupational data base similarly organized, specific occupational displacement rates can be derived, as illustrated in table 1. Although the overall job displacement rate of 1.1 to 2.0 percent through 1990 is not particularly problematical, specific industry and occupation displacement rates are very significant, even dramatic.

To begin with, the displacement rate derived for the auto industry in Michigan ranged from 2.6 to 4.3 percent of all employment. But when displacement was calculated only against the operatives and laborers in the auto industry, the magnitude of displacement was from 5.1 to 8.6 percent. Even when considered to be over a period of a decade, these rates of job displacement *are* significant.

When specific occupational displacement rates are calculated, even more striking results emerge. Our results suggest that between 15 and 20 percent of the welders in the auto industry will be displaced by robots by 1990. Even more dramatically, between 30 and 40 percent of the production painter jobs in the auto industry will be eliminated by 1990. While displacement results are generally less significant for specific occupations in all other manufacturing, it is still projected that 6 to 10 percent of the production painter jobs will be lost here in the same time frame.

The conclusion of the job displacement estimates is that while job displacement due to robots will not be a general problem before 1990, there will clearly be particular areas that will be significantly affected. Chief among these will be the painting and welding jobs for which today's robots are so well adapted. Lesser impacts will be apparent on metalworking machine operatives and assemblers.

We do not believe that this job displacement will lead to significant job loss among the currently employed, however. Even in the auto industry, voluntary turnover rates historically have been sufficient to handle the reduction in force that might be required. In addition, the new General Motors-United Auto Workers contract seems to provide adequate job security assurances, and the retraining commitment necessary to back them up. Thus we do not expect any substantial number of auto workers to be thrown out of work due to the application of robots. Any unemployment impact is likely to be felt by the labor market entrants who will find more and more factory gates closed to the new employee.

JOB CREATION IN MICHIGAN BY 1990

Unquestionably, the most surprising finding is that slightly over two-thirds of the workers in robot manufacturing are in the traditional "white collar" areas of professional, technical, administrative, sales and clerical workers; while only one-third are in the traditional "blue colar" areas of skilled craft workers, production operatives, and laborers. To some extent that is simply a reflection of a young high technology industry with low sales, where the firms tend to be assemblers with little fabrication of parts. However, it is also indicative of a product that cannot be sold like a loaf of bread; there are significant requirements for engineering design, programming and installation for *each* specific application.

By 1990 we foresee the direct creation of from 5,000 to 18,000 jobs in Michigan in four broad areas: robot manufacturing, direct suppliers to robot manufacturers, robot systems engineering, and corporate robot users (auto and all other manufacturing). The jobs in corporate robot users identify maintenance requirements for robots, while the jobs in robot systems engineering identify the applications engineering requirements for robot systems, without regard to industry of employment.

The range of uncertainty is wide in the case of job creation because, in addition to the question of the robot sales level, there is also a question of Michigan's share in robot production in 1990. We attempted to bracket that figure as we did earlier with the robot population. In the case of robot production, our projected Michigan range is from 20 to 40 percent of U.S. production. In 1981 robot manufacturers with Michigan production facilities accounted for nearly one-fifth of the approximately $150 million in U.S. sales of robots.

TABLE 1

Displacement Impact of Robots in Michigan by Application, Cumulative 1978 to 1990

Application	Autos		All other manufacturing		Total	
	1978 employment level	Displacement range (percent)	1978 employment level	Displacement range (percent)	1978 employment level	Displacement range (percent)
Welding	14,910	15.2-19.5	22,694	2.0- 3.6	37,604	7.2- 9.9
Assembly	65,764	4.5- 9.5	50,678	0.8- 2.4	116,442	2.9- 6.4
Painting	4,378	29.2-40.6	4,387	6.0-10.3	8,765	17.6-25.4
Machine loading/unloading	42,149	8.4-13.5	86,906	1.7- 3.2	129,055	3.9- 6.6
All operatives and laborers	206,927	5.1- 8.6	397,598	0.7- 1.5	604,525	2.2- 4.0
All employment	409,506	2.6- 4.3	769,841	0.4- 0.8	1,179,347	1.1- 2.0

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